

[illegible]

- ☐ Information Disclosure Statement
- ☐ Form PTO-1449
- ☐ Special Comments

**6. Declaration or oath**

- Enclosed and executed by
  - all of the inventors
  - ☐ legal representative of inventor(s) 37 CFR 1.42 or 1.43
- ☐ Not Enclosed

**7. Assignments**

- Assignments of the invention to Pearl I, LLC (two)
  - are attached
  - ☐ will follow

**8. Certified Copy**

Certified copy(ies) of application(s)

(country)	(application no.)	(filed)
(country)	(application no.)	(filed)

from which priority is claimed

- ☐ is(are) attached.
- ☐ will follow

**9. Fee Calculation**

CLAIMS AS FILED					
Type of Claim	Number Filed	Included in Basic Fee	Number Extra	Rate	Total Fee
Total Claims	<u>47</u>	-20 =	<u>27</u> x	\$18 =	\$ <u>486.00</u>
Independent Claims	<u>4</u>	-3 =	<u>1</u> x	\$80 =	\$ <u>80.00</u>
Multiple Claims				=	\$ <u>          </u>
Basic Filing Fee				=	\$ <u>710.00</u>
Sub-Total				=	\$ <u>1276.00</u>
Small Entity Filing Fee=				=	\$ <u>638.00</u>

10. **Small Entity Status**

- ☒ Pearl I, LLC is a small entity.

Filing Fee Calculation (50% of regular filing fee) \$ 638.00

11. **Fee Payment**

- ☐ Not Enclosed  
☒ Enclosed

**Total Basic Filing Fees To Be Paid** \$ 638.00

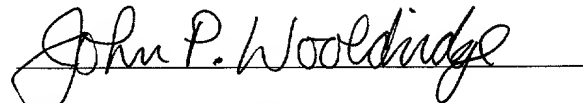
12. **Method of Payment of Fees**

- ☐ Check in the Amount of \$ \_\_\_\_\_  
☒ Charge Account No. 501330 in the amount of \$ 638.00

**A duplicate of this transmittal is attached.**

13. **Instructions As To Overpayment/Underpayment**

- ☒ credit/charge  
Account No. 501330  
☐ refund



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Dated: October 19, 2000

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Pearl I, LLC

Attorney Docket No. : P1-15

Serial No. :

Art Unit:

Filed :

Examiner:

For : INTEGRATED WINE QUALITY SENSOR

Commissioner for Patents  
Washington, D.C. 20231

EXPRESS MAIL CERTIFICATE"Express Mail" label number EK741816910USDate of Deposit: October 19, 2000I hereby certify that the following *attached*

1. New Application Transmittal (in duplicate);
2. Combined Declaration and Power of Attorney (two);
3. Assignments (two);
4. Recordation Cover Sheets (two);
5. Application;  
(Specification 18 pages, Claims 14 pages, Abstract 1 page)  
Six (6) sheets of formal drawings;
6. Express Mail Certificate;
7. Return postcard

is being deposited with the United States Postal Service "Express Mail Post Office to addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner for Patents, Box: Patent Application, Washington, D.C. 20231.

Teresa Wooldridge

(Type or print name of person mailing paper)



(Signature of person mailing paper or fee)

## INTEGRATED WINE QUALITY SENSOR

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### BACKGROUND OF THE INVENTION

#### Field of the Invention

The present invention relates to wine production and inspection methods, and more specifically, it relates to a device and method for evaluating the condition and state of wine while still in the bottle. This device can be easily used to measure specific properties important to the taste and quality of the wine.

#### Description of Related Art

Archeological clues suggest that grapes were cultivated as far back as 4000 B.C. Stronger glass, tighter stoppers, and Louis Pasteur's research into fermentation in the 19<sup>th</sup> century allowed the production of wine to develop into the huge commercial industry that it is today. All wine whether still, sparkling, fortified, or aromatized is fermented grape juice. Wine may be red, white, or pink, dry, medium, or sweet in style with an alcohol content of 5.5% to 14%. Grape spirit may be added to fortified wine, raising the alcohol level to 15% to 22%. Sparkling wine contains trapped carbon dioxide (CO<sub>2</sub>) bubbles that are released upon opening.

Over 44 different varieties of grapes are used to make the most popular wines, either singly or in combination with one another. This gives rise to an incredible number of possible chemical mixture compositions from one type of wine to another. The chemistry of wine can be complex. Many factors influence the final wine product including the type of grape, age of the grapes, the growing conditions, harvest method and many other factors. As grapes ripen, their acid level usually declines while sugar, color, and tannin levels increase. A wine's need for acidity must be balanced with the desire for richness gained from ripeness. There are numerous exogenous chemicals, which may be added to wines such as, sulfur dioxide ( $\text{SO}_2$ ); a sulfite may be added to control oxidation and kill unwanted bacteria. Additionally, it is important to measure the sulfur dioxide concentration to determine wine age and quality. The color of wine, and content of anthocyanins decreases with increasing free sulfur dioxide content -  $\text{SO}_2$ . It is also important to monitor phenol content as the wine will take on a bad odor if ethyl phenol  $>400 \mu\text{g}/\text{l}$  or vinyl phenols  $>725 \mu\text{g}/\text{l}$  are present. Many wines are clarified (fined), using agents such as egg whites, gelatin, isinglass (protein from fish), liquid tannin, charcoal, and certain clays. Sorbic acid may be added to inhibit the growth of yeast and bacteria in sweet wines. Ideally acid, alcohol, fruit and tannins should be balanced. Insufficient acidity makes a wine dull (flat and short); excessive acidity makes the wine sharp and raw tasting. An excess of tannins usually makes a wine bitter, but the right amount of both acidity and tannins produces a wine that is refreshing and that has a flavor that lingers. Spoilage of wine is associated with oxidative mechanisms. Increased  $\text{O}_2$  content greater than  $40 \text{ mg}/\text{l}$  triggers precipitation of excess tannins. Balance can alter with time. Weight refers to the

alcohol content of the wine and body refers to the mixture of fruitiness and alcohol (the feel of it in the mouth). A “well-bodied” wine is alcoholic and fruity, and white wine is crisp with low alcohol content.

The fermentation process for wine usually takes place in two parts. The first part of fermentation is usually conducted in the presence of air and is aerobic.

Fermentation conducted in the absence of air is generally the second portion of the process. Wine can turn to vinegar when vinegar bacteria are allowed access to the wine. Infected equipment, fruit or the vinegar fly (*Drosophila*) may cause the wine to turn. A fermentation trap or airlock may be employed to protect the ferment. The fermentation trap will let gas pressure escape but admit no air. The fermentation trap can also be used to cut off the air supply and force the yeast to turn to a secondary method of self-reproduction without oxygen, which is appreciably more productive of alcohol. The airlock can also act as an indicator as to when fermentation is finished. During the fermentation process yeast must have sugar, warmth, oxygen and a certain amount of nitrogenous matter, vitamins and some acid. If the recipe does not provide all of these or even if any one of them is lacking, the ferment may stick, or temporarily stop. Some fermentation processes are so specific that yeast are laboratory cultured from the yeasts or grapes from the place of the origin of the wine that is desired to be made.

The process of forming wine in casks or vats is also extremely specific. Occasionally, a third fermentation (Malo-Lactic) occurs. This usually happens a year or more after the wine has been bottled. The optimum pH level for wine is usually 3.2 but may vary between 3.0 to 3.4. The low acidity prevents the production of many

chemical species associated with wine spoilage and the growth of microorganisms.

One of the earliest and most sensitive indicators of wine spoilage or impending spoilage is the rise in pH. Increased pH reduces the stability of the anthocyanin pigments and leads to early loss of color. Coupled with spectroscopic analysis of color, pH changes should increase the sensitivity of the measurements for determining aging or spoiling of the wine. Pasteurization is usually implemented to stabilize wine.

The effect of aging wine in the bottle is associated with a color shift from red to brown. Red wines initially deepen in color after fermentation but later take on a lighter ruby then a reddish-brown hue. Decreased color intensity and browning result from a disassociation of anthocyanin complexes (found in young wines) and the progressive formation of anthocyanin-tannin polymers.

The use of new technology has brought about greater control over all stages of wine making, thus reducing production times but also driving up the production costs. The use of stainless steel has become very important to the wine industry in that it allows rigorous temperature control, as well as an inert environment to manipulate the chemistry while preserving the wine's purity. Stainless steel also aids in the strict hygiene requirements of the wine industry. Hygiene is important from a practical standpoint as well as chemically since bacterial contamination may convert the wine to acetic acid and thus vinegar. Although, the exact procedure for bottling wine varies, the bottling usually takes place in a sterile environment and is usually fully automated. Bottling equipment is both complex and expensive since it is important to minimize aeration and agitation. There are several different types of seals that may be placed



over the bottle to prevent oxygen from getting to the wine and reduce spillage. Wine corks are generally made from cork-oak bark that can occasionally become infected with unwanted microorganisms resulting in the wine tasting musty or woody. Plastic and reconstituted corks are an inexpensive alternative and are used mostly on modest wines.

A method and apparatus is needed to accurately and efficiently measure specific properties important to the taste and quality of wine while still in the bottle. International Publication No. WO 93/17324 dated September 2, 1993 provides an apparatus and method for analyzing the alcohol content of beer and wine. This method only monitors the alcohol content and no other chemicals. Also, this method is not concerned with the alcohol content after bottling; rather the monitoring would only take place during the production process.

With technological improvements and the ever increasing popularity of wine, as well as the high prices commanded by certain specialty wines, it would be useful to have an exact measurement of the chemistry of the wine contained within a specific bottle. These measurements could then be compared to the standardized norms and/or authenticated for the purposes of reducing counterfeiting of wines and utilizing the wine before it is beyond its peak of quality. In a commercial, retail or restaurant setting this would prevent sales, delivery or opening and presentation of wines that have become spoiled.

There is a need for a sensor integrated into beverage bottles that can be easily probed to determine the state of the beverage. The present invention fulfills this need, and further provides related advantages.

## SUMMARY OF THE INVENTION

It is an object of the present invention is to provide a sensor system and method for measuring the condition of wine while still in the bottle.

5 In particular, the system can be used to quickly determine the state of wine by measuring a wide variety of wine qualities (e.g., alcohol, sugar, pH, etc.). These measurements can be monitored on a regular basis and used to determine the optimum time to open the bottle and drink the wine. Since individual tastes are different, the user can base the decision on their personal analysis of the measured parameters.

10 The present invention can be used to measure the quality and state of wine that is still in the bottle. A handheld measuring device is placed on a sensor package that may be integrated into the bottle either on the glass or within the seal. In one embodiment, the sensor is fused or bonded to the glass of the bottle where a hole allows the sensor to contact the wine and take measurements. In order to prevent wine contamination, the sensor element could be coated with a polymer. When the sensor package is integrated into the seal (e.g., cork) of the wine bottle, the sensor element can be placed directly in or within a few millimeters of the wine. The wine diffuses into the cork and the sensor can measure the wine content as well as minimize the risk of contamination. The device measures the chemical make-up of the wine. Values are  
15  
20 displayed on the handheld device, allowing the user to determine the condition of the wine.

The sensor elements that comprise the internal side of the sensor package incorporate fiber optics and electrochemical sensors to allow a wide variety of measurements. Measurement of scattered light can be used to determine the presence of solid material in the wine. Additional wine properties (e.g., pH, alcohol, dissolved oxygen) are measured by electrochemical or optical chemical sensors placed between the fibers.

A hinged cover can be used on the sensor package to protect the fiber optic and electrical connectors on the package. A sensor number can be included on the inside of the cover and can be input into the measuring device to be used to accurately interpret the measurements. The handheld measuring device and the sensor package will only operate when the electrical and optical connections are properly aligned. This configuration is possible for the sensor package whether the sensor package is fused to the bottle or integrated into the cork.

The handheld measuring device is comprised of a housing that fits around the sensor package to insure proper contact during the measuring process. The device is battery powered and includes a microprocessor and LCD display. Alternate displays may be used, e.g., an OLED. When activated, the microprocessor reads the digitized signal from all of the sensors and displays the data on the electronic display. Also contained within the device is a broad wavelength light source that transmits light down an optical fiber into the sensor package and transmits through the wine and back into the optical detector. Sensor electronics power the electrochemical sensors. The number of sensors used would be determined by the size and cost of the device. In

order to avoid wine contamination it would be necessary to consider the type of sensors employed.

In one embodiment of the invention, all the sensor data measured by the device can be downloaded into a computer where it can be stored for future comparison. The computer can also be used to download information from the winery about interpretation of the sensor readings for each individual wine type. In order to improve interpretation of sensor data and eliminate effects of sensor drift, each winery can maintain a group of control bottles. Each year a bottle is first measured using the present invention and then opened to measure all properties accurately using proven laboratory techniques. The results are used to post information on the Internet that can be downloaded by consumers to calibrate their own measurements. With time, the consumer will also develop a library of what sensor readings are optimum for their particular tastes.

Although this disclosure describes in detail the use of this invention for wine, a similar system could be used for other alcoholic beverages.

These and other objects will be apparent to those skilled in the art based on the teachings herein. Other objects and advantages of the present invention will become apparent from the following description and accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated into and form part of this disclosure, illustrate embodiments of the invention and together with the description, serve to explain the principles of the invention.

5                   **Figure 1** shows a way the device may be used to measure the state of wine within a bottle.

**Figure 2** shows a sectional view of an embodiment of the wine sensor, as it could be integrated into a bottle.

**Figure 3** shows a sectional view of the wine sensor, as it would be integrated into the cork of a wine bottle.

**Figure 4** shows a view of the internal side of a sensor package.

**Figure 5** shows a view of the external side of a sensor package.

**Figure 6** is a schematic illustration of an embodiment of the handheld measuring device.

15                   **Figure 6** shows the absorption spectra of three red wines of different ages.

## DETAILED DESCRIPTION OF THE INVENTION

**Figure 1** illustrates how an embodiment of the present invention can be used to measure the state of wine in a bottle. The measuring device **10** is placed on the sensor package **20**, which is integrated into the bottle **30**. The user would then use the values read from display **12** on the measuring device **10** to determine the condition of the wine.

Figure 2 shows a cross sectional view through the sensor package 20 and the bottle 30. The sensor package 20 is fused or bonded to the glass of the bottle where a hole allows the sensor elements 40 to contact the wine. The sensor elements can be coated with a polymer to reduce any risk of wine contamination.

Figure 3 show how the sensor package 20 can be integrated into the cork 50 of the wine bottle 30. In this embodiment, the sensor elements 40 can be directly in contact with the wine or be within a few millimeters of the end of the cork. Since wine diffuses into the cork, sensors within a few millimeters of the end of the cork can sample the wine and minimize the risk of wine contamination. In another embodiment, the sensor package 20 is placed in the region between the cork and the bottle.

Figure 4 shows a view of one embodiment of the sensor elements 40 that forms part of the internal side of the sensor package 20. This embodiment incorporates fiber optics and electrochemical sensors to allow a wide variety of measurements. Light transmitted into the input fiber 100 by the measuring device 10 (Figure 1) is reflected by a corner cube 120 that directs the light through another corner cube 140 into a secondary fiber 150. In the bottle, wine fills the gap between the two corner cubes allowing the absorption spectrum of the wine to be measured by the measuring device 10 (Figure 1). In order to improve light coupling between the two fibers, GRIN or other miniature lenses can be added to each fiber optic. An additional fiber 160 collects scattered light off corner cube 170. The measurement of scattered light can be used to determine the presence of solid material in the wine. Instead of using corner

cubes (120, 140, 170) to redirect the light, it would also be possible to bend the optical fibers. This would require the fiber optic to extend further into the bottle to prevent excessive loss of light through the sharp bend.

Electrochemical sensors 180 or optical chemical sensors 190 placed between the fibers are used to measure additional wine properties (e.g., pH, alcohol, dissolved oxygen). Liquid phase chemical sensors generally use enzymatic layers that are extremely selective to a given substrate and highly effective in increasing the rate of reactions. The enzyme is generally immobilized inside a layer into which the substrate diffuses. A wide variety of liquid phase chemical sensors currently exist which can be employed in the present invention (See e.g., "Handbook of Modern Sensors", by Jacob Fraden 1996, and "Handbook of BioSensors and Electronic Noses Medicine, Food and the Environment", ed Erika Kress-Rogers, 1996, incorporated herein by reference). Electrochemical sensors produce a voltage or current that is proportional to a measured quantity. Optical sensors use changes in absorption or fluorescence to measure molecular concentration or fluid property.

Figure 5 shows a view of the external side of one embodiment of the sensor package 20. This embodiment includes a hinged cover 200 that protects the fiber optic 210 and electrical connectors 220 on the package. Rather than a hinged cover a simple cap can be used. In addition, the inside of the cover contains a sensor number 230 that can be input into the measuring device and used to accurately interpret the measurements. Electrical and optical connection between the measuring device and the sensor package is only possible when the device is properly aligned. In Figure 5, the

sensor package is shown bonded to the bottle 30, a similar configuration is possible for a sensor package integrated into the cork of the bottle.

Figure 6 shows a schematic illustration of an embodiment of the handheld measuring device 10. The device comprises a housing 300 that fits around the sensor package to insure proper contact for the duration of the measurement. The fiber optic 310 and electrical connection pins 315 protrude beyond the base plate 320 to dock with the sensor elements on the sensor package. Within the battery powered measuring device, software controls the operation of a microprocessor 330. The microprocessor receives inputs from the user through buttons 340, and displays menus and results on a LCD display 350 (shown as element 12 in Figure 1). When activated, the microprocessor 330 reads the digitized signal from all sensors. The microprocessor 330 can include an integrated analog to digital converter or require a separate analog to digital converter IC. The collected readings are analyzed by the software and displayed on the LCD display 350. In addition, for single property measurements, the measured absorption spectrum can also be displayed on the LCD display 350 as a graph.

A broad wavelength light source 360 within the device transmits light down an optical fiber 365 that goes into the sensor package and is transmitted through the wine and collected back into optical detector 370. Optical detector 370 can be a linear CCD coupled to a grating spectrometer to enable the fluorescence and/or absorption spectrum of the wine to be measured over a wavelength region extending from 300-1300 nm. Optical detector 370 could also be a set of individual filtered optical diodes



that would measure the fluorescence and/or absorption characteristics at a few discrete wavelengths. The standard method of measurement is to calculate a ratio of optical density measurements at 520 nm and 420 nm. A review of the characteristic changes in the overall spectrum suggests that a scan from 350 to 600 nm contain information relative to the aging of the wine (Figure 7). Another optical detector within the device measures the light collected by fiber 170 (Figure 4).

An excitation light source 380 couples light into a fiber optic splitter 385 that sends light down to the optional fiber optic chemical sensors 190 (Figure 4). The resulting fluorescence signal returns from the sensor package and is detected by an optical detector 390. Sensor electronics 400 power the electrochemical sensors 180 (Figure 4) and condition the signal for the analog to digital converter. The number of sensors is only constrained by the size and target cost of the device. In addition, the type of sensor is constrained by the requirement that little or no contamination of the wine occurs.

In the preferred embodiment all the sensor data measured by the device can be downloaded into a computer where it can be stored for future comparison. The computer can also be used to download information from the winery about interpretation of the sensor readings for each individual wine type. In order to improve interpretation of sensor data and eliminate effects of sensor drift, each winery can maintain a group of control bottles. Each year a bottle is first measured using the present invention and then opened to measure all properties accurately using proven laboratory techniques. The results are used to post information on the Internet that can

be downloaded by consumers to calibrate their own measurements. With time the consumer will also develop a library of what sensor readings are optimum for their particular tastes.

Examples of the types of data, indicative of wine quality, that may be sensed by the present invention include galacturonic acid, gums – polysaccharides of arabinose and galactose; tartaric acid, malic acid, citric acid, succinic acid, lactic acid, acetic acid, potassium bitartrate, formic, Yair Margalit, Pacid, oxalic acid, pyruvic acid, butyric acid, iso-butyric acid, hexanoic acid, octanoic acid,  $\alpha$ -Ketoglutaric acid, ethanol, methanol, methyl ester, n-propanol, isopropanol, n-butanol, isobutanol, n-amyl alcohol, 3-methylbutanol, 2-methylbutanol, n-hexanol, 2-phenylethanol, polyalcohols (polyols), 2,3-butandiol, glycerol, erythritol, xylitol, arabitol (also called arabinitol), mannitol, acetaldehyde, acetoin and diacetyl, acetate, butyrate, oxanoate and other esters, ethyl acetate, ethyl formate, propyl acetate, isopropyl acetate, isobutyl acetate, isoamyl acetate, phenylethyl acetate, ethyl propionate, ethyl valerate, ethyl hexanoate (caproate), ethyl octanoate (caprylate), ethyl decanoate (caprate), ethyl lactate, ethyl succinate (acidic ester), methyl o-anthranilate, amino acids, diammonium phosphate, proteins, nitrates, amino acid esters, vitamins, biotin, choline, gallic acid, coumaric acid, caffeic acid, ferulic acid, catechin, epicatechin, gallo catechin gallate, procyanidin (B1, B2, B3), catechin catechin gallate, hydroxycinnamic acid esters (coumaric, caffeic, ferulic), acids, glutathionyl caffeic acid, catechin+epicatechin, catechin-gallate, afzelechin, catechin, epicatechin, and gallo catechin, flavane (3,4) diol, flavonol-3, cyanidin, delphinidin, peonidin, petunidin, malvidin, anthocyanins, glycoside, catechin, epicatechin, potassium, sodium, calcium, iron, lithium, magnesium, copper,

lead, manganese, aluminum, zinc, rubidium, arsenic, nickel, anions, phosphate, sulfate, borates, silicates, halogens, fatty acids, boron, fluorine, silicon, phosphate, sulfate, chlorine, bromine, iodine, anions, sulfur dioxide, acetaldehyde-bisulfite (bound SO<sub>2</sub>), fumaric acid, vinylbenzene, benzaldehyde,  $\gamma$ -nonalactone, ethyl phenylacetate, p-hydroxybenzoic acid, p-pyrocatechuic acid, gallic acid, vanillic acid, syringic acid, salicylic acid, o-pyrocatechuic acid, gentisic acid, cinnamic acid, cinnamic acid, p-coumaric acid, caffeic acid, ferulic acid, sinapic acid, coumaric acid, caffeic acid, fertaric acid, digallic acid, ellagic acid, flavonoids, afzelechin, catechin, galocatechin, glycosides, tannins, flavylum ion, anthocyanins, pelargonidin, cyanidin, delphinidin, peonidin, petunidin, malvidin, ethyl acetate, ethyl caproate, terpenoids, glycosides, pyrazines, phenolics, chlorogenic acid, methyl anthranilate, ethyl anthranilate, methyl salicylate, ethyl salicylate, 2-methoxymethyl benzoate, 2-methoxyethyl benzoate, ethyl trans-2-butenoate, ethyl trans-2-hexenoate, ethyl trans-2-octenoate, ethyl trans-2-decenoate, ethyl trans, trans-2,4-decadienoate, ethyl trans, cis-2,4-decadienoate, ethyl trans, trans, cis-2,4,7-decatrienoate, ethyl trans, cis-2,6-dodecadienoate, methyl 3-hydroxybutanoate, ethyl 3-hydroxybutanoate, ethyl 3-hydroxyhexanoate, damascenone, furaneol, methoxyfuraneol, ethyl 3-mercaptopropanoate, trans-2-hexen-1-ol, hydrogen disulfide, carbon disulfide, dimethyl disulfide, dimethyl sulfide, diethyl sulfide, diethyl disulfide, methanethiol, ethanethiol, dimethyl sulfoxide, methyl thiolacetate, ethyl thiolacetate, cis and trans-2-methylthiophan-3-ol, 5-[hydroxyethyl]-4-methylthiazole, thio aliphatic alcohols, methanionol, or 3-(methylthio)-propanol, polyphenoloxidases, laccase, chlorogenic acid, protocatechuic acid, glutathione, 2-S-

glutathionylcaftaric acid, acetaldehyde, 13C-Norisoprenoids, 1,1,6-trimethyl-1,2-dihydronaphthalene (TDN), vitispirane, ellagic acid, lignins, gallic acid, aromatic aldehydes, vanillin, syringaldehyde, coniferylaldehyde, sinapaldehyde,  $\gamma$ -lactones, cis- $\beta$ -methyl- $\gamma$ -lactone, trans- $\beta$ -methyl- $\gamma$ -lactone, maltol, cyclotene, ethoxylactone, furfural, furfuryl alcohol, Guaiacol, geosmin, anthocyanine-bisulfite, malvidin glucoside, quinones, tartaric acid, potassium bitartrate, calcium tartrate, fumaric acid, calcium carbonate, sorbic acid, ethyl sorbate, benzoic acid and sodium benzoate, diethyl dicarbonate (DEDC), dimethyl dicarbonate (DMDC), iron, copper, aluminum, hydrogen sulfide, mercaptan, diethyl sulfide, ethyl mercaptan, (1)pH, diacetyl, acetoin, 2,3-butandiol, 2-ethoxyhexa-3,5-diene, histamine, tyramine, putrescine, cadaverine, ethyl carbamate, urea and carbamyl phosphate.

The wide use of cork as wine stopper started only at the middle of the 17<sup>th</sup> century. It is related (truly or not) to a monk named Dom Perignon who looked for a solution to secure his sparkling wine in a closed container. Since then the innovation of cork became one of the most important contributions to the development of the wine industry. The production of cork stoppers is a long process. Boiling eliminates insects and other living objects from the bark, and it also removes polyphenols and other volatile substances. The bars are cut into strips, washed and bleached. After grading, the corks undergo surface treatment with various food grade coating materials (paraffin, silicon oil, wax). The object of surface coating is to ease the insertion of the cork into the bottle, and also to ease the later extraction when the bottle is opened. The corks are then sealed in plastic bags containing SO<sub>2</sub> gas to ensure some sterility on

shipment. The phenomenon of corktaint or "corkiness" is characterized by a moldy/musky/smoky off-flavor. The components found in corks which might be responsible for corktaint are: 2,4,6-Trichloroanisole, o-Hydroxyanisole, 1-octen-3-one and 1-octen-3-ol, Trans-1,10-dimethyl-trans-9-decalol, 2-methylisoborneol and TCA (trichloroacetic acid). The present invention is usable for measurement of these and other components indicative of the state or quality of a cork while it is still in the bottle. **Figure 3** provides one example of an embodiment that is readily adaptable to this use. Examples of the variety of materials that may be used for the seal include cork, plastics (polymerized urethanes, vinyls, styrenes, etc.), rubbers, resins, waxes, cellulose, cellulose derivatives, synthetic organic compounds (such as nylon), silicones, silicone derivatives, epoxies and glues.

The above descriptions and illustrations are only by way of example and are not to be taken as limiting the invention in any manner. One skilled in the art can substitute known equivalents for the structures and means described. The full scope and definition of the invention, therefore, is set forth in the following claims.

We claim:

1. A wine quality sensor, comprising:

means for sensing data indicative of wine quality; and

means for measuring and quantifying said data.

2. The wine quality sensor of claim 1, wherein said means for sensing data comprises a sensor package having at least one sensor for sensing said data.

3. The wine quality sensor of claim 2, wherein said sensor package is configured for integration into a wine bottle.

4. The wine quality sensor of claim 1, wherein said means for measuring and quantifying said data comprises a measuring package.

5. The wine quality sensor of claim 3, wherein said wine bottle is formed of glass, wherein said bottle may be sealed with a seal after it is filled with wine, wherein said sensor package is integrated into said seal with a sensor integration configuration selected from the group consisting of (i) integration of said sensor package within said

5 glass, (ii) integration of said sensor package within said seal and (iii) integration of said sensor package between said seal and said glass.

6. The wine quality sensor of claim 5, wherein said seal is selected from the group consisting of a cork, plastics, rubbers, resins, waxes, cellulose, cellulose derivatives, synthetic organic compounds, silicones, silicone derivatives, epoxies and glues.

7. The wine quality sensor of claim 1, wherein said data is selected from the group consisting of alcohol, sugar, pH, dissolved oxygen, an optical transmission spectrum, an optical fluorescence spectrum, an optical scattering coefficient, SO<sub>2</sub>, and phenol.

8. The wine quality sensor of claim 4, wherein said measuring package comprises means for displaying said at least one wine quality value.

9. The wine quality sensor of claim 8, wherein the displaying means comprises an LCD display.

10. The wine quality sensor of claim 8, wherein said measuring package is configured for portable handheld operation.

11. The wine quality sensor of claim 3, wherein said wine bottle is formed of glass, wherein said at least one sensor is fused or bonded to said glass.

12. The wine quality sensor of claim 11, wherein said bottle comprises a hole that allows said at least one sensor to contact wine contained within said bottle.

13. The wine quality sensor of claim 2, wherein said at least one sensor is selected from the group consisting of an electrochemical sensor, an optical chemical sensor and a liquid phase chemical sensor.

14. The wine quality sensor of claim 2, wherein said at least one sensor comprises at least one sensor element.

15. The wine quality sensor of claim 14, wherein said at least one sensor element comprises a polymer coating.

16. The wine quality sensor of claim 14, wherein said data comprises an absorption spectrum of the wine, wherein said at least one sensor element comprises means for measuring said absorption spectrum of the wine.

17. The wine quality sensor of claim 16, wherein said means for measuring said absorption spectrum comprises a light path that traverses the wine.



511

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320

23. The wine quality sensor of claim 17, further comprising means for measuring scattered light.

24. The wine quality sensor of claim 2, wherein said means for measuring said data comprises a microprocessor that reads said at least one sensor.

25. The wine quality sensor of claim 2, further comprising a housing that fits around and encloses said measuring means, wherein said measuring means comprises a measuring package for measuring said data, wherein said measuring package comprises:

at least one light source to provide light to said sensor package;

at least one fiber optic for transmitting light from said at least one light source to said sensor package and for receiving light from said sensor package;

at least one detector for detecting said light;

means for providing power to said at least one sensor;

an LCD display to display menus and said data; and

a microprocessor to control said wine quality sensor.

26. The wine quality sensor of claim 25, wherein said at least one light source comprises a broadband light source.

27. The wine quality sensor of claim 25, wherein said at least one detector is selected from the group consisting of a linear CCD coupled to a grating spectrometer and a filtered optical diode to enable the fluorescence and/or absorption spectrum of the wine to be measured over a wavelength region extending from 300-1300 nm and a set of individual filtered optical diodes that measure fluorescence and/or absorption characteristics at discrete wavelengths.

28. The wine quality sensor of claim 25, wherein said powering means comprises a battery.

29. The wine quality sensor of claim 25, wherein said microprocessor includes an analog to digital converter selected from the group consisting of an integrated analog to digital converter and a separate analog to digital converter IC.

30. The integrated wine quality sensor of claim 25, further comprising an external computer, further comprising means for connecting said microprocessor to said external computer, wherein said data can be downloaded into said external computer where it can be stored for future comparison.

31. The wine quality sensor of claim 2, wherein said sensor package comprises a cover selected from the group consisting of a hinged cover and a cap, wherein said cover protects said sensor package.

32. The wine quality sensor of claim 31, wherein said cover includes a sensor number for identification of said sensor and for obtaining calibration data.

33. The wine quality sensor of claim 1, wherein said data is selected from the group consisting of galacturonic acid, gums – polysaccharides of arabinose and galactose; tartaric acid, malic acid, citric acid, succinic acid, lactic acid, acetic acid, potassium bitartrate, formic, Yair Margalit, Pacid, oxalic acid, pyruvic acid, butyric acid, iso-butyric acid, hexanoic acid, octanoic acid, a-Ketoglutaric acid, ethanol, methanol, methyl ester, n-propanol, isopropanol, n-butanol, isobutanol, n-amyl alcohol, 3-methylbutanol, 2-methylbutanol, n-hexanol, 2-phenylethanol, polyalcohols (polyols), 2,3-butandiol, glycerol, erythritol, xylitol, arabitol (also called arabinitol), mannitol, acetaldehyde, acetoin and diacetyl, acetate, butyrate, oxanoate and other esters, ethyl acetate, ethyl formate, propyl acetate, isopropyl acetate, isobutyl acetate, isoamyl acetate, phenylethyl acetate, ethyl propionate, ethyl valerate, ethyl hexanoate (caproate), ethyl octanoate (caprylate), ethyl decanoate (caprate), ethyl lactate, ethyl succinate (acidic ester), methyl o-anthranilate, amino acids, diammonium phosphate, proteins, nitrates, amino acid esters, vitamins, biotin, choline, gallic acid, coumaric acid, caffeic acid, ferulic acid, catechin, epicatechin, gallic acid gallate, procyanidin (B1,

B2, B3), catechin catechin gallate, hydroxycinnamic acid esters (coutaric, caftaric, fertaric), acids, glutathionyl caftaric acid, catechin+epicatechin, catechin-gallate, afzelechin, catechin, epicatechin, and gallocatechin, flavane (3,4) diol, flavanol-3, cyanindin, delphinidin, peonidin, petunidin, mallvidin, anthocyanins, glycosic, catechin, epicatechin, potassium, sodium, calcium, iron, lithium, magnesium, copper, lead, manganese, aluminum, zinc, rubidium, arsenic, nickel, anions, phosphate, sulfate, borates, silicates, halogens, fatty acids, boron, fluorine, silicon, phosphate, chlorine, bromine, iodine, anions, sulfur dioxide, acetaldehyde-bisulfite (bound SO<sub>2</sub>), fumaric acid, vinylbenzene, benzaldehyde,  $\gamma$ -nonalactone, ethyl phenylacetate, p-hydroxybenzoic acid, p-pyrocatechuic acid, gallic acid, vanillic acid, syringic acid, salicylic acid, o-pyrocatechuic acid, gentisic acid, cinnamic acid, cinnamic acid, p-coumaric acid, caffeic acid, ferulic acid, sinapic acid, coutaric acid, caftaric acid, fertaric acid, digallic acid, ellagic acid, flavonoids, afzelechin, catechin, gallocatechin, glycosides, tannins, flavylum ion, anthocyanins, pelargonidin, cyanidin, delphinidin, peonidin, petunidin, mallvidin, ethyl acetate, ethyl caproate, terpenoids, glycosides, pyrazines, phenolics, chlorogenic acid, methyl anthranilate, ethyl anthranilate, methyl salicylate, ethyl salicylate, 2-methoxymethyl benzoate, 2-methoxyethyl benzoate, ethyl trans-2-butenoate, ethyl trans-2-hexenoate, ethyl trans-2-octenoate, ethyl trans-2-decenoate, ethyl trans, trans-2,4 decadienoate, ethyl trans, cis-2,4 decadienoate, ethyl trans, trans, cis-2,4,7-decatrienoate, ethyl trans, cis-2,6-dodecadienoate, methyl 3-hydroxybutanoate, ethyl 3-hydroxybutanoate, ethyl 3-hydroxyhexanoate, damascenone, furaneol, methoxyfuraneol, ethyl 3-

mercaptopropanoate, trans-2-hexen-1-ol, hydrogen disulfide, carbon disulfide, dimethyl disulfide, dimethyl sulfide, diethyl sulfide, diethyl disulfide, methanethiol, ethanethiol, dimethyl sulfoxide, methyl thiolacetate, ethyl thiolacetate, cis and trans-2-methylthiophan-3-ol, 5-[hydroxyethyl]-4-methylthiazole, thio aliphatic alcohols, methanionol, or 3-(methylthio)-propanol, polyphenoloxidases, laccase, chlorogenic acid, protocatechuic acid, glutathione,, 2-S-glutathionylcaftaric acid, acetaldehyde, <sup>13</sup>C-Norisoprenoids, 1,1,6-trimethyl-1,2-dihydronaphthalene (TDN), vitispirane, ellagic acid, lignins, gallic acid, aromatic aldehydes, vanillin, syringaldehyde, coniferyaldehyde, sinapaldehyde,  $\gamma$ lactones, cis- $\beta$ -methyl- $\gamma$ -lactone, trans- $\beta$ -methyl- $\gamma$ -lactone, maltol, cyclotene, ethoxylactone, furfural, furfuryl alcohol, Guaiacol, geosmin, anthocyanine-bisulfite, malvidin glucoside, quinones, tartaric acid, potassium bitartrate, calcium tartrate, fumaric acid, calcium carbonate, sorbic acid, ethyl sorbate, benzoic acid and sodium benzoate, diethyl dicarbonate (DEDC), dimethyl dicarbonate (DMDC), iron, copper, aluminum, hydrogen sulfide, mercaptan, diethyl sulfide, ethyl mercaptan, (1)pH, diacetyl, acetoin, 2,3-butandiol, 2-ethoxyhexa-3,5-diene, histamine, tyramine, putrescine, cadaverine, ethyl carbamate, urea and carbamyl phosphate.

34. A method for measuring wine quality, comprising:  
sensing data indicative of wine quality; and  
measuring and quantifying said data.

35. The method of claim 34, wherein the step of sensing data includes sensing data selected from the group consisting of an optical transmission spectrum, an optical fluorescence spectrum, an optical scattering coefficient, galacturonic acid, gums – polysaccharides of arabinose and galactose; tartaric acid, malic acid, citric acid, succinic acid, lactic acid, acetic acid, potassium bitartrate, formic, Yair Margalit, Pacid, oxalic acid, pyruvic acid, butyric acid, iso-butyric acid, hexanoic acid, octanoic acid, a-Ketoglutaric acid, ethanol, methanol, methyl ester, n-propanol, isopropanol, n-butanol, isobutanol, n-amyl alcohol, 3-methylbutanol, 2-methylbutanol, n-hexanol, 2-phenylethanol, polyalcohols (polyols), 2,3-butanediol, glycerol, erythritol, xylitol, arabitol (also called arabinitol), mannitol, acetaldehyde, acetoin and diacetyl, acetate, butyrate, oxanoate and other esters, ethyl acetate, ethyl formate, propyl acetate, isopropyl acetate, isobutyl acetate, isoamyl acetate, phenylethyl acetate, ethyl propionate, ethyl valerate, ethyl hexanoate (caproate), ethyl octanoate (caprylate), ethyl decanoate (caprate), ethyl lactate, ethyl succinate (acidic ester), methyl o-anthranilate, amino acids, diammonium phosphate, proteins, nitrates, amino acid esters, vitamins, biotin, choline, gallic acid, coumaric acid, caffeic acid, ferulic acid, catechin, epicatechin, gallic acid gallate, procyanidin (B1, B2, B3), catechin catechin gallate, hydroxycinnamic acid esters (coumaric, caffeic, ferulic), acids, glutathionyl caffeic acid, catechin+epicatechin, catechin-gallate, afzelechin, catechin, epicatechin, and gallic acid, flavane (3,4) diol, flavonol-3, cyanidin, delphinidin, peonidin, petunidin, malvidin, anthocyanins, glycoside, catechin, epicatechin, potassium, sodium, calcium, iron, lithium, magnesium, copper, lead, manganese, aluminum, zinc,

5  
10  
15  
20



acid, glutathione,, 2-S-glutathionylcaftaric acid, acetaldehyde,  $^{13}\text{C}$ -

Norisoprenoids, 1,1,6-trimethyl-1,2-dihydronaphthalene (TDN), vitispirane, ellagic

acid, lignins, gallic acid, aromatic aldehydes, vanillin, syringaldehyde,

coniferyaldehyde, sinapaldehyde,  $\gamma$ lactones, cis- $\beta$ -methyl- $\gamma$ -lactone, trans- $\beta$ -methyl- $\gamma$ -

lactone, maltol, cyclotene, ethoxylactone, furfural, furfuryl alcohol, Guaiacol, geosmin,

anthocyanine-bisulfite, malvidin glucoside, quinones, tartaric acid, potassium bitartrate,

calcium tartrate, fumaric acid, calcium carbonate, sorbic acid, ethyl sorbate, benzoic

acid and sodium benzoate, diethyl dicarbonate (DEDC), dimethyl dicarbonate

(DMDC), iron, copper, aluminum, hydrogen sulfide, mercaptan, diethyl sulfide, ethyl

mercaptan, (1)pH, diacetyl, acetoin, 2,3-butandiol, 2-ethoxyhexa-3,5-diene, histamine,

tyramine, putrescine, cadaverine, ethyl carbamate, urea and carbamyl phosphate.

36. The method of claim 34, further comprising displaying said data.

37. The method of claim 34, wherein the step of sensing data includes sensing data with at least one sensor selected from the group consisting of an electrochemical sensor, an optical chemical sensor and a liquid phase chemical sensor.

38. The method of claim 34, wherein the step of sensing data includes sensing data with at least one sensor that comprises a polymer coating.

39. The method of claim 34, wherein the step of sensing data includes sensing an absorption spectrum of the wine

40. The method of claim 33, wherein the step of sensing data includes measuring scattered light.

41. The method of claim 33, further comprising downloading said data to an external computer.

42. A wine cork quality sensor, comprising:  
means for sensing data indicative of cork quality; and  
means for measuring and quantifying said data.

43. The wine cork quality sensor of claim 42, wherein said means for sensing data comprises at least one sensor for directly monitoring at least one chemical factor within a cork indicative of cork spoilage.

44. The wine cork quality sensor of claim 43, wherein said at least one chemical factor is selected from the group consisting of 2,4,6-Trichloroanisole, o-Hydroxyanisole, 1-octen-3-one and 1-octen-3-ol, Trans-1,10-dimethyl-trans-9-decalol, 2-methylisoborneol and TCA (trichloroacetic acid).

45. A method for measuring wine cork quality, comprising:

3

3

3

INTEGRATED WINE QUALITY SENSOR

ABSTRACT OF THE DISCLOSURE

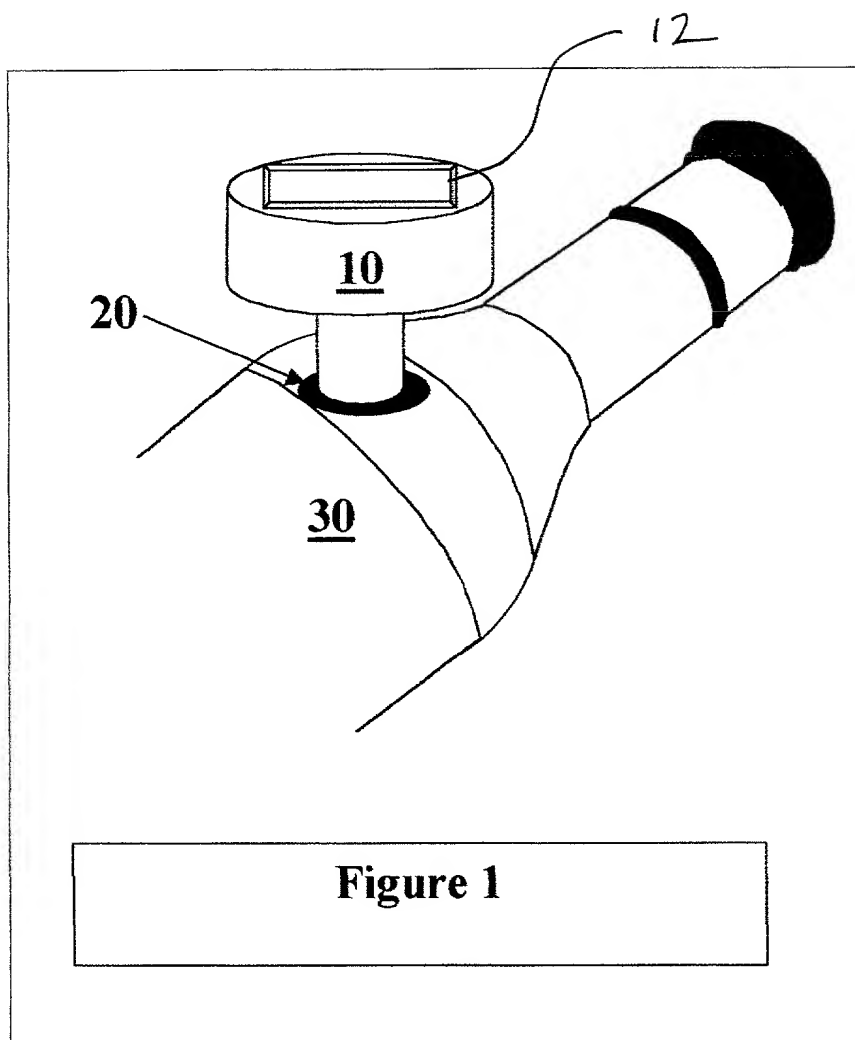
A device is described that can be easily used to evaluate the condition and state of wine while still in the bottle. The device consists of a handheld device that connects to a sensor package on the wine bottle. Optical and/or electrochemical measurements are used to measure specific properties important to the taste and quality of the wine.

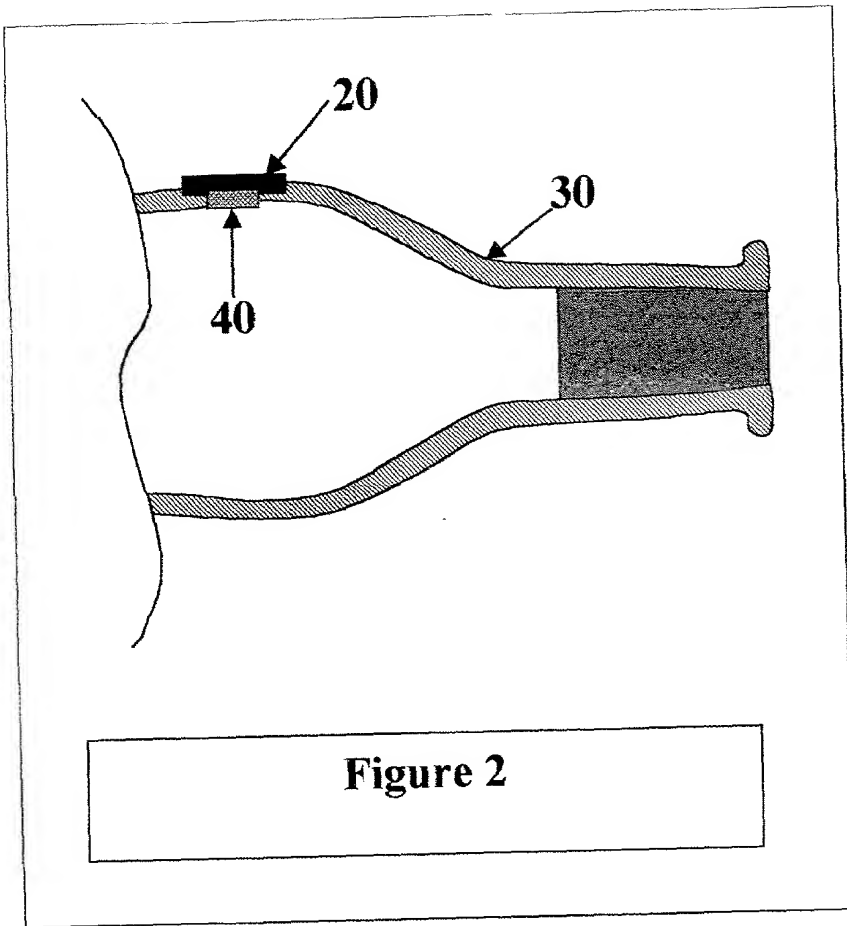
Sacramento, CA 95819

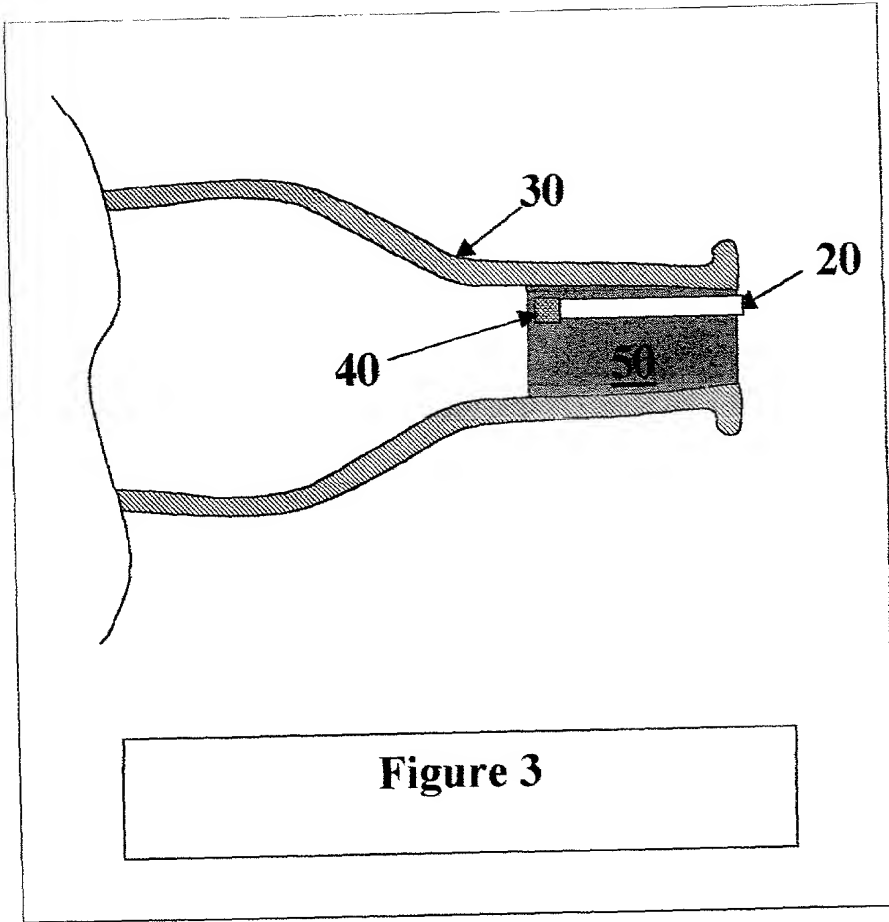
Ft. Lauderdale, Florida 33308

Livermore, California 94550

Danville, CA 94526

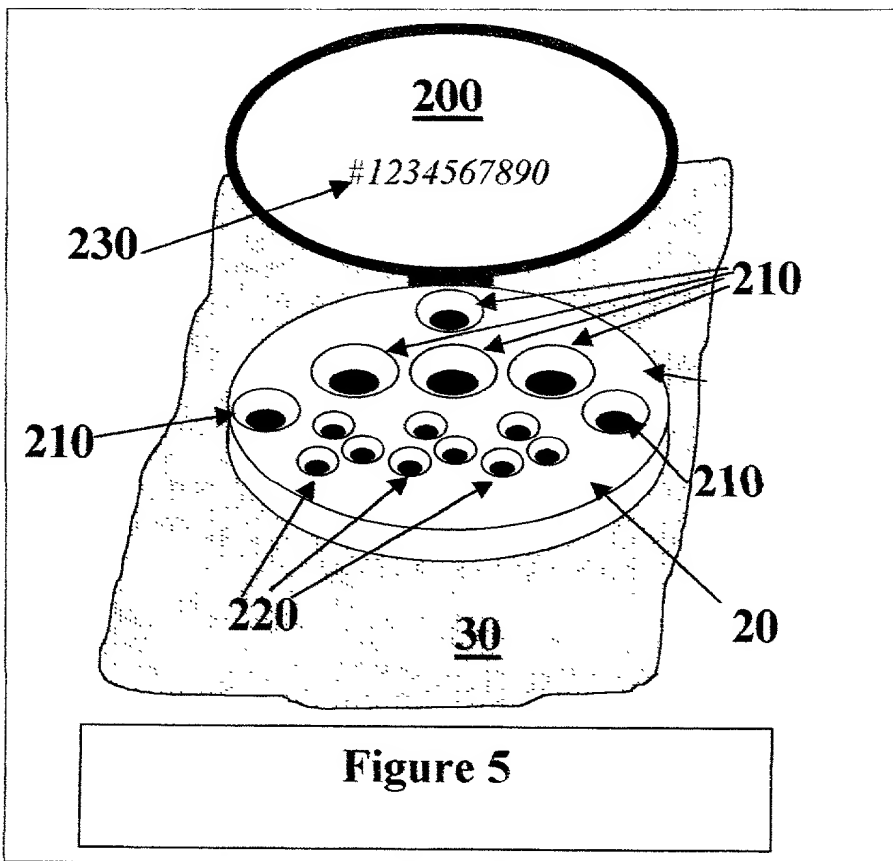
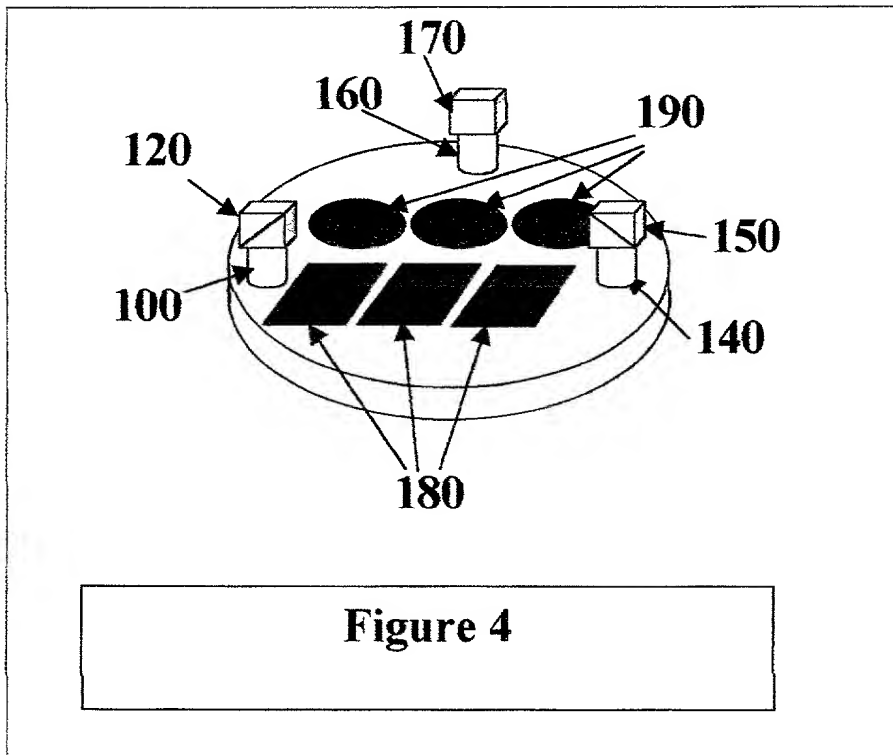


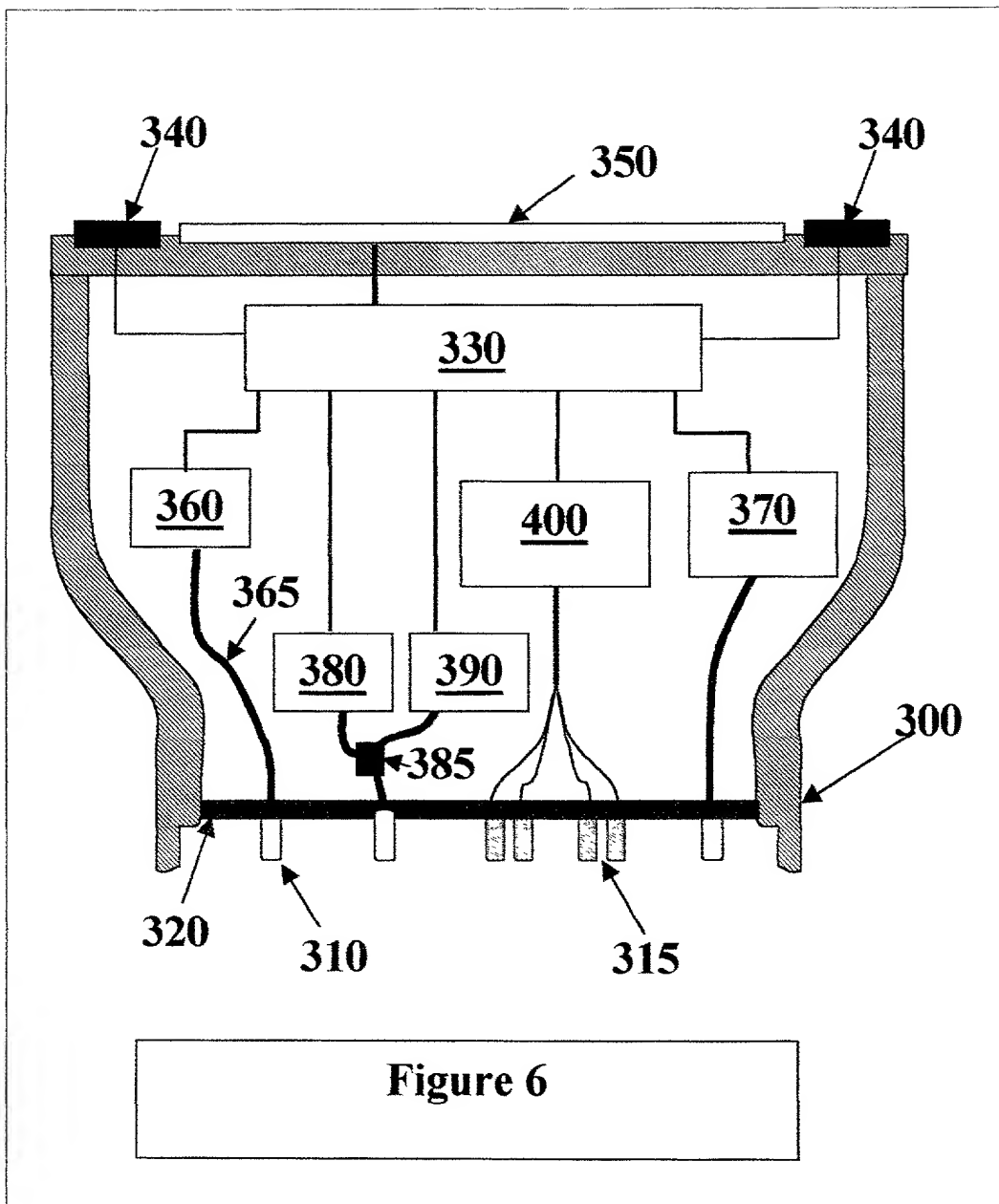




**Figure 3**







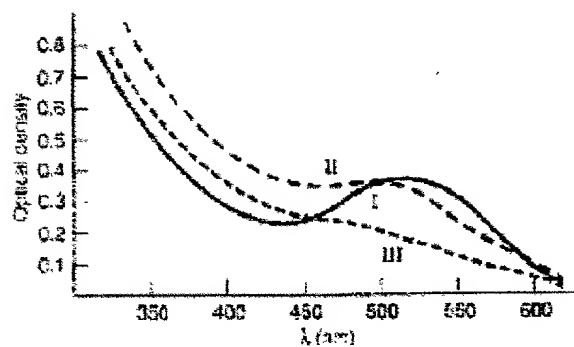


Figure 8.16 Absorption spectra of three red wines of different ages I, 1 year old; II, 10 years old; III, 50 years old (from Ribéreau-Gayon, 1986, reproduced by permission).

Figure 7

## COMBINED DECLARATION AND POWER OF ATTORNEY

- ☒ Declaration submitted  
with Initial Filing
- ☐ Declaration submitted  
after Initial Filing (surcharge  
(37 CFR 1.16(e)) required)

Attorney Docket: P1-15  
Applicant: Pearl I, LLC  
Serial No.:  
Filing Date:

### As a below named inventor(s), I (we) hereby declare that:

My (Our) residence, post office address and citizenship(s) are as stated below next to my (our) name(s).

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:  
INTEGRATED WINE QUALITY SENSOR

the specification of which (check one)

X is attached hereto \_\_\_\_\_ was filed on \_\_\_\_\_ as United States Application  
Number or PCT International Application Number \_\_\_\_\_

and was amended on \_\_\_\_\_ (if applicable).

I (We) hereby state that I (we) have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I (We) acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I (We) hereby claim foreign priority benefits under 35, U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

(Application Number) (Country) (Foreign Filing Date)



(Application Number) (Country) (Foreign Filing Date)



I (We) hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below:

Application Serial No.

Filing Date

I (We) hereby claim the benefit under 35 U.S.C. 120 of any United States applications(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Application Serial No.

Filing Date

Status

**POWER OF ATTORNEY:** As the named inventor(s), I (we) hereby appoint the following registered practitioner(s) to prosecute this application, and to transact all business connected therewith, in any patent office, U.S. or foreign.

Names

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(Name and Telephone Numbers)  
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I (We) hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Citizenship



## COMBINED DECLARATION AND POWER OF ATTORNEY

- ☒ Declaration submitted  
with Initial Filing  
☐ Declaration submitted  
after Initial Filing (surcharge  
(37 CFR 1.16(e)) required)

Attorney Docket: P1-15  
Applicant: Pearl I, LLC  
Serial No.:  
Filing Date:

As a below named inventor(s), I (we) hereby declare that:

My (Our) residence, post office address and citizenship(s) are as stated below next to my (our) name(s).

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:  
**INTEGRATED WINE QUALITY SENSOR**

the specification of which (check one)

X is attached hereto \_\_\_\_\_ was filed on \_\_\_\_\_ as United States Application  
Number or PCT International Application Number \_\_\_\_\_

and was amended on \_\_\_\_\_ (if applicable).

I (We) hereby state that I (we) have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I (We) acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I (We) hereby claim foreign priority benefits under 35, U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

(Application Number) (Country) (Foreign Filing Date)

(Application Number) (Country) (Foreign Filing Date)

I (We) hereby claim the benefit under 35 U.S.C. 119(c) of any United States provisional application(s) listed below:

Application Serial No.

Filing Date

I (We) hereby claim the benefit under 35 U.S.C. 120 of any United States applications(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Application Serial No.

Filing Date

Status

**POWER OF ATTORNEY:** As the named inventor(s), I (we) hereby appoint the following registered practitioner(s) to prosecute this application, and to transact all business connected therewith, in any patent office, U.S. or foreign.

Names

Registration No.

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(Name and Telephone Numbers)  
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I (We) hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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